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Craig D. Edwards

DSTO-TN-0189

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Air Operations Division
Aeronautical and Maritime Research Laboratory

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ABSTRACT

Software has been developed to test the communication between the MicroVAX computer and the bi-directional parallel data bus in the Low Speed Wind Tunnel (LSWT) data acquisition system. It enables reading any combination of data parameters from the bus for a user-defined number of iterations. An output file is created which contains the final values, average bus communication times associated with the read process and a statistical analysis of the recorded data. This report describes the operation of the software and presents results of tests performed on the existing data acquisition configuration.

RELEASE LIMITATION

Approved for public release

DEPARTMENT OF DEFENCE
DEFENCE SCIENCE & TECHNOLOGY ORGANISATION
DSTO

Published by

DSTO Aeronautical and Maritime Research Laboratory
PO Box 4331
Melbourne Victoria 3001 Australia

Telephone: (03) 9626 7000
Fax: (03) 9626 7999

AR-010-843
February 1999

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Executive Summary

The existing Low Speed Wind Tunnel (LSWT) data acquisition software operates directly from a MicroVAX system using a bi-directional parallel communication bus designed at the Aeronautical and Maritime Research Laboratory (AMRL). This bus connects a range of instrumentation modules to the host computer. Previous and current wind tunnel tests indicate that this configuration may not be performing to its maximum potential. Software was developed for testing the MicroVAX/Bus communication to enable a greater understanding of the current capabilities wth the view of improving the system. Communication times were recorded and the integrity of the data acquired from the modules was examined.

Bus communication time was found to be relatively slow in some modules. Acquiring data from the inclinometer module was slow due to the checking of the conversion buffer. This was improved by modifying the inclinometer software to update its database continuously, thus eliminating the need for checking the conversion buffer prior to reading of parameters. A communication time totalling approximately 1.6 seconds was observed when acquiring data from the freestream parameter, inclinometer, actuator, turntable, strain gauge and auxiliary modules. This involved a request of 28 addresses corresponding to a bus communication time of approximately 0.06 seconds per address. Tests were performed with and without the tunnel running and negligible differences in communication times were observed.

Frequent anomalies were evident in the data acquired from the freestream parameter module. When the tunnel was running at 60 m/s, more anomalies were observed than when the tunnel was not running and these may be caused by interference from the wind tunnel's AC drive motor. The other modules functioned at a satisfactory speed usually without any anomalies or poor data.

It is recommended that bus communication, hardware set-up and the software in the freestream parameter module be investigated to determine the causes of the anomalies. Plans to improve the quality of data acquisition and communication are being developed, and these include connecting the instrumentation modules to the MicroVAX via a PC on which the software can be run and the processed experimental data displayed. In this scenario, the MicroVAX would be solely responsible for acquiring raw data from the slave instrumentation modules attached to the bus, and for passing the data to the PC. This would unclutter the operation of the MicroVAX and improve the speed and efficiency of data acquisition.

Contents

1. Introduction

The existing Low Speed Wind Tunnel (LSWT) data acquisition software operates directly from the MicroVAX system using a bi-directional parallel communication bus designed at the Aeronautical and Maritime Research Laboratory (AMRL). This bus connects a range of instrumentation modules to the host computer. Previous and current wind tunnel tests indicate that this configuration may not be performing to its maximum potential. The development of software was proposed to assist in determining an optimum design. It was intended that bus communication would be tested to enable a greater understanding of the capabilities of the MicroVAX system. The timing of bus readings would be analysed, as would any data disturbances that may be associated with interactions between the acquisition modules of the existing system. This data shall assist in determining options for upgrading the present system.

Future plans to improve the quality of data acquisition and communication involve connecting the instrumentation modules to the MicroVAX via a PC on which the software can be run and the processed experimental data displayed. In this scenario, the MicroVAX will be solely responsible for acquiring raw data from the slave instrumentation modules attached to the bus, and for passing the data to the PC.

2. Software Description and User Instructions

The entire listing of the program in Fortran code is included in Appendix A of this document. The following is a description of the workings of the software and a definition of the variables that were used. The designed software consists of two components; the main executable program *'bus_read.for'* and a subroutine *'conv.for'* for the conversion of raw data into the appropriate format to provide realistic values. They run in conjunction with the existing data acquisition software *'digio_include.for'*, *'digiodef.h'* and *'bus_addresses.for'* and the function subprogram *'hextodec.for'*. These files are required for the software being developed to work correctly.

2.1 Selection of Parameters

When the executable program *'bus_read.exe'* is initiated, a menu is displayed which lists the data parameters that can be obtained from the relevant modules via bus communication. The user is prompted to enter, in a continuous string (or separated by commas or spaces), the numbers corresponding to the desired parameters. This response determines the course of action for the remainder of the program. The user is also requested to enter the number of desired iterations, which represents the number of times the bus is interrogated with the selected variables. At present the parameters available for selection are:

1) freestream parameters (from the freestream parameters module)
2) pitch angle (from the inclinometer module)
3) roll angle (from the inclinometer module)
4) yaw angle (from the model attitude module)
5) actuator angles (from the actuator module)
6) strain gauge values (from the AC strain gauge module)

7) motor speed (from the auxiliary module)
8) pitch, roll angles and calculated alpha, beta angles (from the sting column rig module)

However, parameters associated with other configurations can easily be incorporated by simply adding the appropriate lines of code in an identical manner to the existing options.

2.2 Digio Message Assembly

The software tests each character in the selection string, one at a time, for a match with one of the parameter read options. When a match is registered, the bus address indexes pertaining to the parameters to be read are inserted into the digio message (a character string). The start and end character positions in the digio message for each input are recorded incrementally to allow additional addresses to be appended. A counter also updates the total number of addresses in the completed digio message. The file *'bus_addresses.for'* contains all the bus addresses and their definitions that currently exist in the LSWT data acquisition system. This process is repeated for each recognised character within the selection string. If no matches are found, no digio message is compiled and the remainder of the program is bypassed.

Once the required addresses have been assembled, the digio message is completed by adding to the beginning, a priority index (usually 'H' - high), the requestor index, and the total number of addresses the message contains. Using the character string of the parameters selected, a header describing the parameters that will be read from the bus is compiled and written to a file.

2.3 Bus Communication and Data Acquisition

Before the parameters are read from the bus, a command is sent which triggers all of the modules. If either the inclinometer module or strain gauge module is required, then the conversion buffers for these modules are checked. A series of built-in functions sends the digio message to the bus which then obtains the data to be read and places it in the array, *data_list()*. This bus communication time is then calculated using the system subroutine *secnds*.

Following this process, the subroutine, *conv.for,* is called which converts the raw data obtained from the bus into engineering values. The data may have to be converted from hex to decimal format and a scale factor introduced before a meaningful result can be observed. The final values are then written to the output file *'test.dat'* beneath the appropriate headings determined previously. Bus communication time is also listed to indicate the speed with which the process was performed. According to the number of iterations specified by the user at the start, the same digio message is repeatedly sent to the bus to acquire data and output it in an identical manner. The average bus communication time for the sending of one digio message and the average time per address is then computed.

2.4 Statistical Analysis

To determine the quality of data collected and the number of anomalies that exist, if any, a statistical analysis is then performed. A tolerance value is set for each column of data according to a typical magnitude. The columns are scanned to record the number of points that lie outside this tolerance band and an average is then calculated ignoring these detected anomalies. Another loop detects any points that deviate from this average by a chosen percentage margin. Both the numbers of anomalies and scattered data are then listed for each column at the base of the output file.

NOTE: The statistical analysis provides interpretable data only if the parameters are read during a period of reasonably steady state when condition changes are minimal.

3. Software Testing and Analysis

Tests were performed to investigate the timing of the bus communication for combinations of different modules in different situations. Times were recorded for cases in which modules were interrogated individually and then compared to the times obtained when reading from multiple modules via a single digio message. Times were also estimated for each address within each module read. It was assumed that this was equal to the total time divided by the number of address indexes in the digio message.

The system response was examined for a number of different arrangements. Typical run configurations were chosen and the tests conducted incorporated only the relevant parameters required for that run. Any interactions that may have occurred among modules were identified by comparing the results obtained. The effects of having *all* modules switched on or only those modules required for the reading of particular parameters were considered. Differences, if any, due to whether or not the tunnel was actually operating, were also investigated.

The following tables contain bus communication times for particular combinations of parameters and the different configurations as described above. Comparisons were made and graphs were created to illustrate these results. The numbers used to tabulate the data more conveniently, correspond to the relevant parameters as defined below.

3.1 Definition of Parameters

1 = six freestream parameters (ten addresses from the freestream parameters module):

- -tunnel test section static pressure (P_t)
- -dynamic pressure (q)
- -air speed (v)
- -air temperature (t)
- -Mach number (M)
- -Reynolds number (Re)

2 = pitch angle (from the inclinometer module)
3 = roll angle (from the inclinometer module)
4 = yaw angle (from the turntable module)
5 = eight actuator angles (from the actuator module)
6 = six strain gauge values (from the AC strain gauge module)
7 = motor speed (from the auxiliary module)
8 = pitch, roll angles and calculated alpha, beta (from the sting column rig module)

3.2 Bus Communication Times

Table 1. Average bus communication times for selected parameters over 100 iterations with all modules on.

		Average Bus Communication Times, Δt (seconds)		
		Tunnel Idle		Tunnel Running
Parameters	Number of Addresses	Average time per iteration	Average time per address	Average time per iteration
1 only	10	0.574	0.057	0.579
2 only	1	0.190	0.190	0.189
3 only	1	0.190	0.190	0.188
4 only	1	0.070	0.070	0.070
5 only	8	0.421	0.053	0.422
6 only	6	0.385	0.064	0.380
7 only	1	0.070	0.070	0.069
8 only	4	0.222	0.056	0.223
2,3 only	2	0.240	0.120	0.250
1,2	11	0.738	0.067	0.740
1,2,3	12	0.792	0.066	0.794
1,2,3,4	13	0.846	0.065	0.847
1,2,3,4,5	21	1.251	0.060	1.254
1,2,3,4,5,6	27	1.545	0.057	1.545
1,2,3,4,5,6,7	28	1.598	0.057	1.598

The times per address listed in Table 1, give an indication of the relative times that were required to read a single measurement from each module. It appears that reading from the inclinometer module is particularly slow when only one parameter (either pitch angle *or* roll angle) is required. Bus time was reduced slightly when both pitch and roll angles were requested. However, it still seems that a considerable amount of time is spent in checking the conversion buffer of this module as indicated by a 0.164 seconds difference between the read results of freestream and pitch angle (1,2) and freestream (1) only. The addition of roll angle (3) only contributes another 0.054 seconds. The time for reading the conversion buffer of the inclinometer module was tested and determined to be approximately 0.130 seconds. These results confirm that the checking of the conversion buffer is responsible for the relatively slow reading of the inclinometer module.

The sting column rig module is similar to the freestream parameter module in that it is PC based. However, the sting column rig user interface operates in an RTKernel environment as opposed to the DOS operating system for the freestream parameters.

Despite this difference, bus communication times per address for each configuration appeared to be similar.

The actuators and strain gauge modules appear to be operating satisfactorily with reasonable times per address of 0.053 and 0.064 seconds respectively.

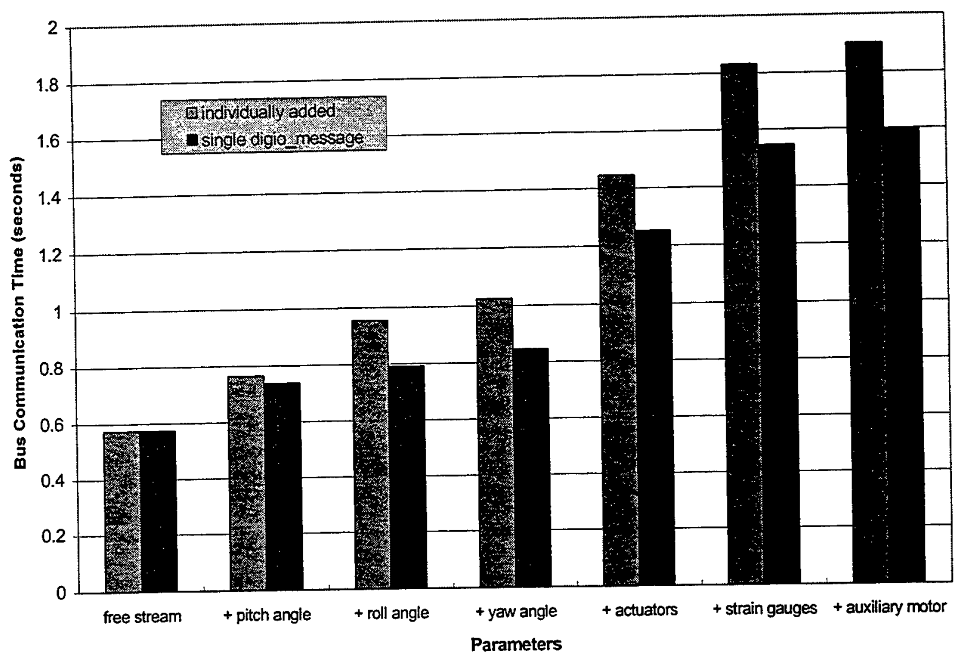

Figure 1. Graph showing the contribution of each parameter towards bus communication time.

The graph shown in Figure 1 illustrates the bus communication times for each module, showing their effectiveness and how the speed of each compares with others. When the single digio message times are compared with the data obtained by adding individual bus times, an indicative time for the actual send command and data transfer can be obtained. A time of approximately 0.05 seconds was determined to be typical for a single send command operation.

A time was also established for the entire bus communication loop and then an average time per iteration was simply calculated by dividing by the number of iterations. This was compared with the times determined previously. A negligible difference of less than 0.001 seconds was estimated.

As expected, whether or not the tunnel was running did not significantly affect the bus communication times.

3.3 Effect on Bus Communication Times Due to the State of the Instrumentation Modules (ON/OFF)

Table 2 shows bus communication times obtained when all modules were switched on compared with those when only the required modules for the selected parameters were activated.

It was determined that activating modules other than those modules required had a negligible effect on average bus communication times.

Table 2. Average bus communication times per iteration over 100 iterations for different module states.

	Average Bus Communication Times, Δt (seconds)	
Parameters	**All modules ON**	**Only required modules ON**
1 only	0.574	0.577
1,2,3	0.777	0.783
1,2,4	0.782	0.796
1,3,4	0.782	0.796
1,2,3,5	1.194	1.200
1,2,3,6	1.101	1.104
1,2,3,5,6	1.495	1.506
1,2,3,5,6,7	1.549	1.557

3.4 Anomalies and Accuracy of Data

The existence and frequency of anomalies within the data for the cases described in Table 1 and Table 2, were observed and recorded. After ignoring these anomalies, an average bus time for the remaining data was calculated. The scatter of data was inspected by determining the number of points that deviated from the computed average by a chosen percentage tolerance.

Example output data of 100 iterations for cases when the tunnel is and is not running is given in Appendix B. The data gives the number and type of anomalies typically present in the freestream parameters during bus communication. This information is summarised in Table 3 and Table 4.

Table 3. Frequency and value of anomalies in the freestream parameters when the tunnel is not running.

	Tunnel Idle, v = 0.0 m/s			
Freestream Parameters (1)	**Number of Anomalies**	**≈ Anomaly value**	**Hexadecimal Equivalent**	**≈ Expected Value**
Static pressure, P_t	8	316.15	7B7F	101.05
Dynamic pressure, q	3	2 069 824.	7B5F 0200	0.0
Air velocity, v	0	-	-	0.0
Air temperature, t	14	316.13	7B7D	23.1
Mach Number, M	1	2069.593	7B5D 7BA8	0.0
Reynolds Number, Re	2	2.07×10^9	7B61 B180	0.0

Table 4. Frequency and value of anomalies in the freestream parameters when the tunnel is running with an air speed of 60 m/s.

	Tunnel Active, v = 60.0 m/s			
Freestream Parameters (1)	**Number of Anomalies**	**≈ Anomaly value**	**Hexadecimal Equivalent**	**≈ Expected Value**
Static pressure, P_t	8	316.15	7B7F	101.37
Dynamic pressure, q	3	2 069 824.	7B5F 0200	2219.
Air speed, v	7	2.07×10^7	7B61 B180	60.0
Air temperature, t	16	316.13	7B7D	17.5
Mach Number, M	1	2069.593	7B5D 7BA8	0.131
Reynolds Number, Re	1	2.07×10^9	7B61 B180	4 103 890.

It appears that anomalies are relatively frequent among the freestream parameters. Although the data listed in the tables are representative of one test only, many tests were performed and the same trend was observed. The number of anomalies varied but they were always of a similar magnitude. The number of anomalies was generally lower in the parameters v, M and Re, and minimal in the case when the tunnel was idle. Similar trends were observed when the wind tunnel speed was increased to 30 m/s. When the tunnel was running at 60 m/s, anomalies were usually more abundant. This increase in poor data may be attributed to the AC drive motor, which must be activated to attain a tunnel speed of 60 m/s. The values of the anomalies appeared to always follow a similar pattern (as shown in the tables) and hence the hexadecimal equivalents are included as a reference.

Because the sting column rig operates under a different PC based environment (Kernel) to the freestream parameter module, data obtained from the sting column rig was also examined for a similar trend. It was observed that the reading of pitch angle continuously produced false values. Only on three occasions from 100 iterations in a typical test, was the pitch angle read from the bus correctly. Otherwise, anomalies were almost non-existent compared with those reported for the freestream parameter module.

Results of occasional tests on different days produced extremely irregular data in the freestream parameters even after the bus and all systems had been reset. This output was nonsensical and contained few values bearing any likeness to expected measurements. Reasons for the meaningless data obtained during these times have yet to be determined.

3.5 Corrective Actions Taken

To increase the speed of the inclinometer module, modifications were made to the inclinometer module software so that it updated its database continuously. This eliminates the need for checking the conversion buffer before data is read from the bus. Although this modification will cause a slight time delay so that values read may lag the instantaneous physical position, this time delay is of the order of microseconds and is insignificant to the overall response. More tests were conducted to verify that the previously determined slow response of the inclinometer module was due to the checking of the conversion buffer. Results indicated that authentic data was recorded consistently and the bus communication time per address was

reduced to 0.071 seconds for reading either the pitch or roll angle, and 0.121 seconds for reading both.

4. Conclusions and Recommendations

Bus communication time was found to be relatively slow in some modules. This was true in the inclinometer module where the slow time was due to checking the conversion buffer. This was improved by modifying the inclinometer software to update its database continuously, thus eliminating the need for checking the conversion buffer prior to reading the parameters. Frequent anomalies were evident in output data of the freestream parameters in all tests. However, the other modules such as the actuators, strain gauges, model attitude and auxiliary modules appeared to function at a satisfactory speed and usually without any anomalies or poor data.

Despite the different PC operating environment, bus communication with the sting column rig was similar in speed to that of the freestream parameter module. However, the reading of the pitch angle in the sting column rig almost always resulted in an incorrect value. Otherwise, very few anomalies were observed in the data compared with the many discrepancies detected in nearly all of the freestream parameters from the freestream parameter module.

It is recommended that bus communication, hardware set-up and the software in the freestream parameter module be investigated to determine the causes of the anomalies. One possible way of improving data acquisition and communication is to connect a PC with the MicroVAX system. User instructions and input could then be performed on the PC and the raw and processed experimental data obtained could also be viewed. This will unclutter the operation of the MicroVAX and improve the speed and efficiency of data acquisition.

Appendix A - Developed Software in Fortran Code

```
      program bus_read

c-------------------------------------------------------------------
c     Author:    Craig Edwards
c     Date:      29 March 1996
c
c     This program allows the user to interrogate a particular
c     combination of modules in the LSWT data aquisition system.  It
c     compiles a digio_message from the user selection, communicates
c     with the bus and writes the output to a file 'test.dat' for a
c     user specified number of iterations.  The average bus communication
c     time for reading a digio message is also recorded.  A statistical
c     analysis is then performed on the collected data.  The number of
c     anomalies and data points which lie outside a chosen tolerance band
c     are computed and written to the output file.
c
c-------------------------------------------------------------------

      include '[datain.digio]digio_include.for'
      include '[datain.digio]digiodef.h'

c     external     ss$_wasset

      real                deltat(1000), oldtime, accuracy, error
      real                average(50), values(50), tol, store(0:16)
      real                temp
      real                data(50,1000), sum(50), tsum, tsuma, tsumb
      integer*4    mposition, mcounter, num, iter, mlength,m
      integer*4    a, ecounter, most, b(0:16)
      integer*2    dlist(1000,1000)
      real                deltata(1000), deltatb(1000)
      real                oldtime_total, time_total, oldtimeb

c     integer*4    mbox_write_code
c     integer*4    status,
c     1            sys$clref,
c     2            sys$wflor,
c     3            sys$qiow,
c     4            sys$setef

      character    selection*10, digio_message*256
      character*15        d(50)

      logical             pitch, roll, yaw, acts, sgs, motor
      logical             cont, scr

c     parameter    (mbox_write_code = '70'X)

      CALL connect

      OPEN(1,file='test.dat',status='new',carriagecontrol='list')

      write(6,*)
      write(6,*) ' Choose parameters to be read:'
      write(6,*)
      write(6,*) '        1) free stream parameters'
      write(6,*) '        2) pitch angle (inclinometer module)'
      write(6,*) '        3) roll angle (inclinometer module)'
      write(6,*) '        4) yaw angle (turntable module)'
      write(6,*) '        5) actuators'
      write(6,*) '        6) strain gauges'
      write(6,*) '        7) motor speed (propellor)'
      write(6,*) '        8) sting-column rig'
      write(6,*)
      write(6,10)
 10   format('$ >> ')
      read(5,20) selection
 20   format(a)
      write(6,30)
 30   format(/'$ Enter number of iterations: ')
      read(5,*) iter
```

```
C*****************************************************************************

      pitch = .false.
      roll = .false.
      yaw = .false.
      acts = .false.
      sgs = .false.
      motor = .false.
      scr = .false.

      mposition = 7
      mcounter = 0
      m = 0

      DO j=1,len(selection)

c-------------------------------------------------------------------------
c   Standard P,q,V,T,M,Re (free stream parameters)
c-------------------------------------------------------------------------

          IF (selection(j:j).eq.'1') THEN
          digio_message(mposition:mposition+49) =
     1    ' 478  493  494  484  485  479  495  496  486  487'

          d(m+1) = '       p        '
          d(m+2) = '       q        '
          d(m+3) = '       v        '
          d(m+4) = '       t        '
          d(m+5) = '       m        '
          d(m+6) = '      re        '

          mposition = mposition+50
          mcounter = mcounter+10
          m = m+6

c-------------------------------------------------------------------------
c   Pitch, Roll, Yaw angles
c-------------------------------------------------------------------------

          ELSEIF (selection(j:j).eq.'2') THEN
          pitch = .true.
          digio_message(mposition:mposition+4) = '  158'

          d(m+1) = '     THETA      '

          mposition = mposition+5
          mcounter = mcounter+1
          m = m+1

          ELSEIF (selection(j:j).eq.'3') THEN
          roll = .true.
          digio_message(mposition:mposition+4) = '  157'

          d(m+1) = '      PHI       '

          mposition = mposition+5
          mcounter = mcounter+1
          m = m+1

          ELSEIF (selection(j:j).eq.'4') THEN
          yaw = .true.
          digio_message(mposition:mposition+4) = '  652'

          d(m+1) = '      PSI       '

          mposition = mposition+5
          mcounter = mcounter+1
          m = m+1

c-------------------------------------------------------------------------
c   Actuator angles
c-------------------------------------------------------------------------

          ELSEIF (selection(j:j).eq.'5') THEN
          acts = .true.
          digio_message(mposition:mposition+39) =
```

```
     1        '  812   822   832   842   852   862   872   882'

        d(m+1)  =  '        a1         '
        d(m+2)  =  '        a2         '
        d(m+3)  =  '        a3         '
        d(m+4)  =  '        a4         '
        d(m+5)  =  '        a5         '
        d(m+6)  =  '        a6         '
        d(m+7)  =  '        a7         '
        d(m+8)  =  '        a8         '

        mposition = mposition+40
        mcounter = mcounter+8
        m = m+8

c-----------------------------------------------------------------------
c   Force measurement - Strain Gauges
c-----------------------------------------------------------------------

        ELSEIF (selection(j:j).eq.'6') THEN
        sgs = .true.
        digio_message(mposition:mposition+29) =
     1        '  102   103   104   105   106   107'

        d(m+1)  =  '       sg1         '
        d(m+2)  =  '       sg2         '
        d(m+3)  =  '       sg3         '
        d(m+4)  =  '       sg4         '
        d(m+5)  =  '       sg5         '
        d(m+6)  =  '       sg6         '

        mposition = mposition+30
        mcounter = mcounter+6
        m = m+6

c-----------------------------------------------------------------------
c   Powered Propellor
c-----------------------------------------------------------------------

        ELSEIF (selection(j:j).eq.'7') THEN
        motor = .true.
        digio_message(mposition:mposition+4) = '  190'

        d(m+1)  =  '       RPS         '

        mposition = mposition+5
        mcounter = mcounter+1
        m = m+1

        ELSEIF (selection(j:j).eq.'8') THEN
        scr = .true.
        digio_message(mposition:mposition+24) =
     1           '  710   711   712   713'

        d(m+1)  =  '     alpha         '
        d(m+2)  =  '     beta          '
        d(m+3)  =  '     theta         '
        d(m+4)  =  '      phi          '

        mposition = mposition+25
        mcounter = mcounter+4
        m = m+4

        ENDIF

      ENDDO

      IF (mcounter.ne.0) THEN

c-----------------------------------------------------------------------
c   Complete digio_message
c-----------------------------------------------------------------------

      mlength = mposition-1
      digio_message(1:1) = 'H'
      write(digio_message(2:3),100) requestor_index
  100 format(1x,i1)
```

```
      write(digio_message(4:6),110) mcounter
110   format(1x,i2)

      write(1,*) (d(k), k=1,m), '    deltat   '
      write(1,*) '-------------------------------------'
      1    ,'-------------------------------------'

      oldtime_total = secnds(0.0)
      DO i=1,iter

          oldtime = secnds(0.0)

c--------------------------------------------------------------------------
c   Send trigger to ADC's
c--------------------------------------------------------------------------

          CALL send ('H',1,2,status)
          deltata(i) = secnds(oldtime)

c--------------------------------------------------------------------------
c   Check conversion buffer of the SG amplifier module
c--------------------------------------------------------------------------

          oldtimeb = secnds(0.0)
          IF (sgs) THEN

          ii = 0
          data_list(data_start_addr) = 'AAAA'X
          DO WHILE  ((data_list(data_start_addr) .NE. 0) .AND.
      1           (ii .LT. 50))
              CALL send ('H',1,101,status)
              ii = ii + 1
          END DO

          ENDIF

c--------------------------------------------------------------------------
c   Check conversion buffer of the inclinometer module
c--------------------------------------------------------------------------

c         IF ((pitch).or.(roll)) THEN
c
c         ii = 0
c         data_list(data_start_addr) = 'AAAA'X
c         DO WHILE ((data_list(data_start_addr) .NE. 0) .AND.
c     1           (ii .LT. 50))
c             CALL send ('H', 1, 169, status)
c             ii = ii + 1
c         END DO
c
c         ENDIF

          deltatb(i) = secnds(oldtimeb)

c--------------------------------------------------------------------------
c   Bus communication
c--------------------------------------------------------------------------

          status = sys$qiow ( , %VAL(digio_mbox_chan),
      1                  %VAL(mbox_write_code), , , ,
      2                  %REF(digio_message),
      3                  %VAL(256), , , ,)
          status = sys$setef ( %VAL(64) )
          status = sys$wflor ( %VAL(64), %VAL(efn_mask) )
          status = sys$clref ( %VAL(efn_success) )
          status = sys$clref ( %VAL(efn_error) )

c         IF (status.eq.%LOC(ss$_wasset)) THEN
c         call type_error
c         ENDIF

          deltat(i) = secnds(oldtime)
          DO iii = 1,1000
          dlist(iii,i) = data_list(iii)
          ENDDO

      ENDDO
```

```
      time_total = secnds(oldtime_total)

      tsum = 0.0e0
      tsuma = 0.0e0
      tsumb = 0.0e0

      DO i = 1,iter

          DO iii = 1,1000
          data_list(iii) = dlist(iii,i)
          ENDDO
          CALL conv(data_list, values, selection, num)

          DO iii=1,num
          data(iii,i) = values(iii)
          ENDDO
c-----------------------------------------------------------------------
c   Output values obtained
c-----------------------------------------------------------------------

          write(1,*) (values(iii), iii=1,num), deltat(i)
          write(1,*) '----------------------------------'
     1    ,'---------------------------------------'

          tsum = tsum + deltat(i)
          tsuma = tsuma + deltata(i)
          tsumb = tsumb + deltatb(i)

      ENDDO

      write(1,*)

      write(1,*) 'Average bus communication time per iteration = '
     1    ,tsum/real(iter)
      write(6,*) 'Average bus communication time per iteration = '
     1    ,tsum/real(iter)

      write(6,*) 'Average bus communication time per iteration = '
     1    ,time_total/real(iter)
      write(6,*) '        (calculated from total time)'

      write(6,*) 'Average bus communication time per iteration = '
     1    ,tsuma/real(iter)
      write(6,*) '        (for triggering of all modules)'

      write(6,*) 'Average bus communication time per iteration = '
     1    ,tsumb/real(iter)
      write(6,*) '        (for reading of conversion buffers)'

      write(1,*)

c-----------------------------------------------------------------------
c   Begin statistical analysis
c-----------------------------------------------------------------------

      accuracy = 5.0              !percentage

      DO iii=1,num
          ecounter = 0
          sum(iii) = 0.
          a = 0

c-----------------------------------------------------------------------
c   Determine tolerance band based on order of magnitude of first
c   point.  Determine what value range exists by majority and set this
c   to the typical value from which anomalies and data accuracy is
c   obtained.  (Needs alteration and improvement)
c-----------------------------------------------------------------------

          DO k=0,16
          b(k) = 0
          ENDDO

          DO j = 1,iter
          cont = .true.
          k = 6
```

```
      DO WHILE ((cont).and.(k.ge.0))
          IF (data(iii,j).gt.2*10.**k) THEN
              b(k) = b(k)+1
              store(k) = data(iii,j)
              cont = .false.
          ELSEIF (data(iii,j).lt.-(2*10.**k)) THEN
              b(k+7) = b(k+7)+1
              store(k+7) = data(iii,j)
              cont = .false.
          ELSEIF (abs(data(iii,j)).lt.0.001) THEN
              b(14) = b(14)+1
              store(14) = data(iii,j)
              cont = .false.
          ELSEIF (abs(data(iii,j)).lt.1.) THEN
              b(15) = b(15)+1
              store(15) = data(iii,j)
              cont = .false.
          ELSEIF (abs(data(iii,j)).lt.2.) THEN
              b(16) = b(16)+1
              store(16) = data(iii,j)
              cont = .false.
          ELSE
              k = k-1
          ENDIF
      ENDDO
      ENDDO

      most = 0
      DO k = 0,16
      IF (b(k).gt.most) THEN
          most = b(k)
          temp = store(k)
      ENDIF
      ENDDO

      IF (temp.lt.0.001) THEN
      tol = 0.0001
      ELSEIF (temp.lt.1.) THEN
      tol = 0.05
      ELSEIF (temp.lt.2.) THEN
      tol = 0.1
      ELSEIF (temp.lt.50.) THEN
      tol = 2.
      ELSEIF (temp.lt.100.) THEN
      tol = 5.
      ELSEIF (temp.lt.1000.) THEN
      tol = 100.
      ELSE
      tol = 1000000.
      ENDIF

c-----------------------------------------------------------------------
c  Record number of anomalies, compute average from remainder and
c  determine the no. of points which deviate from this average.
c-----------------------------------------------------------------------

      DO i=1,iter
      IF (abs(data(iii,i)-temp).gt.tol) THEN
          a = a+1
      ELSE
          sum(iii) = sum(iii) + data(iii,i)
      ENDIF
      ENDDO
      average(iii) = sum(iii) / real(iter-a)

      DO i=1,iter

      IF (abs(average(iii)).gt.0.0001) THEN
          error = ((data(iii,i))-average(iii))
     1            /average(iii) * 100.0
          IF (abs(error).gt.accuracy) THEN
              ecounter = ecounter+1
          ENDIF

      ELSE
          error = data(iii,i)-average(iii)
          IF (abs(error).gt.1.0) THEN
```

```
            ecounter = ecounter+1
         ENDIF
      ENDIF

      ENDDO

c-----------------------------------------------------------------------
c   Output statistics results
c-----------------------------------------------------------------------

      IF ((a.ne.0).or.(ecounter.ne.0)) THEN
      write(1,120) 'DATA COLUMN ',iii
120   format(a,i2)
      ENDIF
      IF (a.ne.0) THEN
      write(1,121) 'There are ',a,' anomalies present'
121   format(t10,a,i3,a)
      ENDIF
      IF (ecounter.ne.0) THEN
      write(1,122) 'There are ',ecounter,' point(s)',
     1      ' with a deviation > ',accuracy,'% from the average'
122   format(t10,a,i3,2a,f4.1,a/)
      ENDIF

   ENDDO

   ENDIF

   CLOSE(1)

   CALL disconnect

   STOP
   END
```

```
subroutine conv(data, values, selection, num)

include '[datain.digio]digio_include.for'
include '[datain.digio]digiodef.h'

integer*2  data(*)
integer*2  mask
integer*4  i4upper, i4lower, hextodec
character  selection*(*)
real                divisor, values(50)
parameter  (mask = '7FFF'X)
parameter  (divisor = 3276.8)

i = data_start_addr
ii = 1

DO j=1,len(selection)

    IF (selection(j:j).eq.'1') THEN
    values(ii) = dfloat(data(i))/100.0

    i4upper = data(i+1)
    i4lower = data(i+2)
    values(ii+1) = dfloat(hextodec(i4upper,i4lower))/1.0e3

    i4upper = data(i+3)
    i4lower = data(i+4)
    values(ii+2) = dfloat(hextodec(i4upper,i4lower))/100.0

    values(ii+3) = dfloat(data(i+5))/100.0

    i4upper = data(i+6)
    i4lower = data(i+6)
    values(ii+4) = dfloat(hextodec(i4upper,i4lower))/1.0e6

    i4upper = data(i+8)
    i4lower = data(i+9)
    values(ii+5) = dfloat(hextodec(i4upper,i4lower))

    i = i+10
    ii = ii+6

    ELSEIF (selection(j:j).eq.'2') THEN

    values(ii) = data(i)/100.
    i = i+1
    ii = ii+1

    ELSEIF (selection(j:j).eq.'3') THEN

    values(ii) = data(i)/100.
    i = i+1
    ii = ii+1

    ELSEIF (selection(j:j).eq.'4') THEN

    values(ii) = data(i)/100.
    i = i+1
    ii = ii+1

    ELSEIF (selection(j:j).eq.'5') THEN

    DO inc = 0,7
        values(ii+inc) = data(i+inc)/100.0
    ENDDO
    i = i+8
    ii = ii+8

    ELSEIF (selection(j:j).eq.'6') THEN

    DO inc = 0,5
        values(ii+inc) = iieor(data(i+inc),mask)/divisor
    ENDDO
    i = i+6
    ii = ii+6
```

```
    ELSEIF (selection(j:j).eq.'7') THEN

    values(ii) = data(i)/10.0

    i = i+1
    ii = ii+1

    ELSEIF (selection(j:j).eq.'8') THEN

    values(ii) = data(i)/100.0
    values(ii+1) = data(i+1)/100.0
    values(ii+2) = data(i+2)/100.0
    values(ii+3) = data(i+3)/100.0

    i = i+4
    ii = ii+4

    ENDIF

ENDDO

num = ii-1

RETURN
END
```

Appendix B - Sample Output Data

Tunnel Idle **Speed = 0.0 m/s**

p	q	v	t	m	re	deltat
316.0700	0.0000000E+00	0.0000000E+00	23.08000	0.0000000E+00	0.0000000E+00	0.6015625
101.0600	0.0000000E+00	0.0000000E+00	23.01000	0.0000000E+00	0.0000000E+00	0.5820313
101.0500	0.0000000E+00	0.0000000E+00	23.00000	0.0000000E+00	0.0000000E+00	0.5625000
101.0600	0.0000000E+00	0.0000000E+00	23.01000	0.0000000E+00	2.0708721E+09	0.5312500
101.0400	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00	0.0000000E+00	0.5429688
101.0400	0.0000000E+00	0.0000000E+00	23.00000	0.0000000E+00	0.0000000E+00	0.5585938
101.0500	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5898438
101.0400	0.0000000E+00	0.0000000E+00	23.08000	0.0000000E+00	0.0000000E+00	0.5507813
101.0600	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00	0.0000000E+00	0.5898438
101.0600	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5820313
101.0400	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5703125
101.0600	0.0000000E+00	0.0000000E+00	23.06000	0.0000000E+00	0.0000000E+00	0.6093750
101.0500	0.0000000E+00	0.0000000E+00	23.04000	0.0000000E+00	0.0000000E+00	0.5820313
101.0400	2069824.	0.0000000E+00	23.01000	0.0000000E+00	0.0000000E+00	0.5585938
101.0500	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00	0.0000000E+00	0.5898438
101.0400	0.0000000E+00	0.0000000E+00	23.08000	0.0000000E+00	0.0000000E+00	0.5820313
101.0600	0.0000000E+00	0.0000000E+00	23.02000	0.0000000E+00	0.0000000E+00	0.5507813
101.0600	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00	0.0000000E+00	0.5390625
316.1500	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5937500
101.0500	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00	0.0000000E+00	0.5820313
101.0600	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.5664063
316.1500	0.0000000E+00	0.0000000E+00	23.06000	0.0000000E+00		

0.0000000E+00	0.5820313			
101.0500	0.0000000E+00	0.0000000E+00	23.10000	0.0000000E+00
0.0000000E+00	0.5585938			
101.0500	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00
0.0000000E+00	0.5898438			
101.0400	0.0000000E+00	0.0000000E+00	23.04000	0.0000000E+00
0.0000000E+00	0.5898438			
101.0400	31.58100	0.0000000E+00	23.01000	0.0000000E+00
0.0000000E+00	0.5781250			
101.0500	0.0000000E+00	0.0000000E+00	23.00000	0.0000000E+00
0.0000000E+00	0.5468750			
101.0400	0.0000000E+00	0.0000000E+00	23.08000	0.0000000E+00
0.0000000E+00	0.5781250			
101.0500	0.0000000E+00	0.0000000E+00	23.01000	2069.593
0.0000000E+00	0.6015625			
101.0600	0.0000000E+00	0.0000000E+00	23.06000	0.0000000E+00
0.0000000E+00	0.6015625			
101.0400	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00
0.0000000E+00	0.5820313			
316.1500	0.0000000E+00	0.0000000E+00	23.06000	0.0000000E+00
0.0000000E+00	0.5820313			
101.0400	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00
0.0000000E+00	0.5625000			
101.0500	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00
0.0000000E+00	0.5820313			
101.0400	0.0000000E+00	0.0000000E+00	23.04000	0.0000000E+00
0.0000000E+00	0.5820313			
101.0600	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00
0.0000000E+00	0.5625000			
101.0400	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00
0.0000000E+00	0.5781250			
101.0500	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00
0.0000000E+00	0.5898438			
101.0400	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00
0.0000000E+00	0.5820313			
101.0400	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00
0.0000000E+00	0.5898438			
101.0600	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00
0.0000000E+00	0.5781250			
101.0500	0.0000000E+00	0.0000000E+00	23.06000	0.0000000E+00
0.0000000E+00	0.5507813			
101.0400	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00
0.0000000E+00	0.5625000			
101.0500	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00
0.0000000E+00	0.5898438			
101.0500	2069824.	0.0000000E+00	23.15000	0.0000000E+00
0.0000000E+00	0.5507813			
101.0600	0.0000000E+00	0.0000000E+00	23.13000	0.0000000E+00
0.0000000E+00	0.5976563			
101.0400	0.0000000E+00	0.0000000E+00	23.05000	0.0000000E+00
0.0000000E+00	0.5585938			

101.0600	0.0000000E+00	0.0000000E+00	23.10000	0.0000000E+00	0.0000000E+00	0.5390625
101.0500	0.0000000E+00	0.0000000E+00	23.06000	0.0000000E+00	0.0000000E+00	0.5820313
101.0400	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5898438
101.0600	0.0000000E+00	0.0000000E+00	23.13000	0.0000000E+00	0.0000000E+00	0.5507813
101.0600	0.0000000E+00	0.0000000E+00	316.0500	0.0000000E+00	0.0000000E+00	0.5625000
101.0600	0.0000000E+00	0.0000000E+00	23.09000	0.0000000E+00	0.0000000E+00	0.5898438
101.0500	0.0000000E+00	0.0000000E+00	23.16000	0.0000000E+00	0.0000000E+00	0.5781250
101.0400	0.0000000E+00	0.0000000E+00	23.13000	0.0000000E+00	0.0000000E+00	0.6210938
101.0500	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5625000
101.0400	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.5703125
101.0400	0.0000000E+00	0.0000000E+00	23.10000	0.0000000E+00	0.0000000E+00	0.5898438
101.0600	0.0000000E+00	0.0000000E+00	23.13000	0.0000000E+00	0.0000000E+00	0.5781250
101.0500	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.5703125
101.0600	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.5820313
101.0600	0.0000000E+00	0.0000000E+00	23.10000	0.0000000E+00	0.0000000E+00	0.5507813
101.0400	0.0000000E+00	0.0000000E+00	23.10000	0.0000000E+00	0.0000000E+00	0.5898438
101.0400	0.0000000E+00	0.0000000E+00	23.17000	0.0000000E+00	0.0000000E+00	0.5976563
101.0400	0.0000000E+00	0.0000000E+00	316.0500	0.0000000E+00	0.0000000E+00	0.5703125
101.0400	0.0000000E+00	0.0000000E+00	23.15000	0.0000000E+00	0.0000000E+00	0.5507813
316.1500	0.0000000E+00	0.0000000E+00	23.17000	0.0000000E+00	0.0000000E+00	0.5585938
101.0500	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.5585938
316.1500	0.0000000E+00	0.0000000E+00	23.13000	0.0000000E+00	0.0000000E+00	0.5429688
101.0400	0.0000000E+00	0.0000000E+00	316.1300	0.0000000E+00	0.0000000E+00	0.5820313
101.0600	0.0000000E+00	0.0000000E+00	316.0500	0.0000000E+00	0.0000000E+00	0.5976563
316.1500	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.5976563
101.0400	0.0000000E+00	0.0000000E+00	23.12000	0.0000000E+00	0.0000000E+00	0.6015625

```
------------------------------------------------------------------------
 101.0600      0.0000000E+00  0.0000000E+00    23.13000      0.0000000E+00
2.0708721E+09  0.5273438
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.13000      0.0000000E+00
0.0000000E+00  0.5390625
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.12000      0.0000000E+00
0.0000000E+00  0.5781250
------------------------------------------------------------------------
 101.0600      0.0000000E+00  0.0000000E+00    23.13000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0400      0.0000000E+00  0.0000000E+00    23.16000      0.0000000E+00
0.0000000E+00  0.5625000
------------------------------------------------------------------------
 101.0400      0.0000000E+00  0.0000000E+00    23.17000      0.0000000E+00
0.0000000E+00  0.5781250
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0400      0.0000000E+00  0.0000000E+00    23.17000      0.0000000E+00
0.0000000E+00  0.5781250
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.13000      0.0000000E+00
0.0000000E+00  0.5585938
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.13000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0400      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5781250
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    316.1300      0.0000000E+00
0.0000000E+00  0.5507813
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.16000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0400      0.0000000E+00  0.0000000E+00    316.1300      0.0000000E+00
0.0000000E+00  0.5820313
------------------------------------------------------------------------
 316.1500      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5390625
------------------------------------------------------------------------
 101.0600      0.0000000E+00  0.0000000E+00    23.17000      0.0000000E+00
0.0000000E+00  0.5820313
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.17000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0600      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5585938
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.16000      0.0000000E+00
0.0000000E+00  0.5820313
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.16000      0.0000000E+00
0.0000000E+00  0.5625000
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
0.0000000E+00  0.5468750
------------------------------------------------------------------------
 101.0400      0.0000000E+00  0.0000000E+00    316.0500      0.0000000E+00
0.0000000E+00  0.5781250
------------------------------------------------------------------------
 101.0500      0.0000000E+00  0.0000000E+00    23.16000      0.0000000E+00
0.0000000E+00  0.5898438
------------------------------------------------------------------------
 101.0600      0.0000000E+00  0.0000000E+00    23.15000      0.0000000E+00
```

```
 0.0000000E+00  0.5781250
--------------------------------------------------------------------------
  101.0500      0.0000000E+00  0.0000000E+00   23.15000      0.0000000E+00
 0.0000000E+00  0.6679688
--------------------------------------------------------------------------

Average bus communication time average =   0.5753515

DATA COLUMN  1
         There are   8 anomalies present
         There are   8 point(s) with a deviation >  5.0% from the average

DATA COLUMN  2
         There are   3 anomalies present
         There are   3 point(s) with a deviation >  5.0% from the average

DATA COLUMN  4
         There are  14 anomalies present
         There are  14 point(s) with a deviation >  5.0% from the average

DATA COLUMN  5
         There are   1 anomalies present
         There are   1 point(s) with a deviation >  5.0% from the average

DATA COLUMN  6
         There are   2 anomalies present
         There are   2 point(s) with a deviation >  5.0% from the average
```

Tunnel Active **Speed = 60 m/s**

p re	q deltat	v	t	m
101.3800 4099761.	2208.208 0.5703125	60.28000	316.1300	0.1310740
101.3800 4099278.	2194.269 0.5390625	60.26000	17.47000	0.1310740
101.3700 4098640.	2209.835 0.6015625	60.27000	17.55000	0.1310740
101.3700 4101715.	2209.835 0.5898438	2.0711658E+07	316.1300	0.1310740
101.3700 4098728.	2209.835 0.5703125	60.30000	17.59000	0.1310740
101.3700 4100828.	2209.846 0.5507813	60.29000	17.57000	0.1310740
101.3700 4099040.	2209.835 0.6015625	60.30000	17.57000	0.1310740
101.3700 4103318.	2209.846 0.5898438	60.31000	17.52000	0.1310740
101.3800 4102311.	2211.465 0.5781250	60.31000	316.1300	0.1310740
101.3700 4099832.	2211.496 0.6015625	60.32000	17.62000	0.1310740
316.1500 4101403.	2211.496 0.5703125	2.0711658E+07	17.53000	0.1310740
101.3700 4099471.	2211.496 0.5507813	60.32000	17.53000	0.1310740
316.1500 4102059.	2213.145 0.5898438	60.35000	17.58000	0.1310740
101.3700 4101698.	2211.496 0.5703125	60.32000	17.59000	0.1310740
101.3700 4103181.	2211.484 0.5468750	2.0711658E+07	17.51000	0.1310740
316.1500 4102820.	2069872. 0.6015625	60.34000	17.53000	0.1310740
101.3700 4102968.	2213.134 0.5898438	60.34000	17.55000	0.1310740
101.3900 4102957.	2213.126 0.5703125	60.34000	17.53000	0.1310740
101.3800 4104597.	2214.765 0.5898438	60.33000	17.52000	0.1310740
101.3700 4100936.	2213.134 0.5468750	60.35000	17.64000	0.1310740
101.3700 4104734.	2214.795 0.5898438	60.37000	17.52000	0.1310740
101.3900 4103836.	2216.468 0.5781250	60.36000	17.57000	0.1310740
101.3700 4103173.	2194.269 0.6523438	60.37000	17.62000	0.1310740
101.3600 4103229.	2214.771 0.5898438	60.38000	17.68000	0.1310740

101.3700	2214.784	60.37000	17.63000	0.1310740
4104128.	0.5703125			
101.3700	2216.433	60.39000	17.58000	0.1310740
4103678.	0.5507813			
101.3700	2214.795	2.0714024E+07	17.58000	0.1310740
4105027.	0.5898438			
101.3700	2214.784	60.38000	17.71000	0.1310740
4102916.	0.6015625			
101.3700	2069877.	60.41000	17.69000	0.1310740
4103278.	0.5898438			
101.3700	2216.445	60.39000	17.59000	0.1310740
4105076.	0.5781250			
101.3800	2216.457	60.37000	17.62000	0.1310740
4104939.	0.6015625			
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4103162.	0.5898438			
101.3800	2216.457	60.39000	17.59000	0.1310740
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4110387.	0.5507813			
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4117142.	0.5781250			
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4118133.	0.5507813			
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4117544.	0.5781250			
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4116149.	0.5507813			
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4117230.	0.6015625			
316.1500	2232.883	60.63000	17.77000	0.1310740
4117230.	1.9531250E-02			

Average bus communication time per iteration = 0.5619922

```
DATA COLUMN  1
         There are   8 anomalies present
         There are   8 point(s) with a deviation >  5.0% from the average

DATA COLUMN  2
         There are   3 anomalies present
         There are   3 point(s) with a deviation >  5.0% from the average

DATA COLUMN  3
         There are   7 anomalies present
         There are   7 point(s) with a deviation >  5.0% from the average

DATA COLUMN  4
         There are  16 anomalies present
         There are  16 point(s) with a deviation >  5.0% from the average

DATA COLUMN  5
         There are   1 anomalies present
         There are   1 point(s) with a deviation >  5.0% from the average

DATA COLUMN  6
         There are   1 anomalies present
         There are   1 point(s) with a deviation >  5.0% from the average
```

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Craig D. Edwards

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1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)

2. TITLE MicroVAX/Bus Communication Testing Software for the Low Speed Wind Tunnel Data Acquisition System	3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION) Document (U) Title (U) Abstract (U)
4. AUTHOR(S) Craig D. Edwards	5. CORPORATE AUTHOR Aeronautical and Maritime Research Laboratory PO Box 4331 Melbourne Vic 3001 Australia

6a. DSTO NUMBER	6b. AR NUMBER	6c. TYPE OF REPORT	7. DOCUMENT DATE
DSTO-TN-0189	AR-010-843	Technical Note	February 1999

8. FILE NUMBER	9. TASK NUMBER	10. TASK SPONSOR	11. NO. OF PAGES	12. NO. OF REFERENCES
M1/9/578	A70257	DSTO	30	0

13. DOWNGRADING/DELIMITING INSTRUCTIONS	14. RELEASE AUTHORITY
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18. DEFTEST DESCRIPTORS

Low speed wind tunnels, Data acquisition, Wind tunnel tests, Vax computers, Computer buses

19. ABSTRACT

Software has been developed to test the communication between the MicroVAX computer and the bi-directional parallel data bus in the Low Speed Wind Tunnel (LSWT) data acquisition system. It enables reading any combination of data parameters from the bus for a user-defined number of iterations. An output file is created which contains the final values, average bus communication times associated with the read process and a statistical analysis of the recorded data. This report describes the operation of the software and presents results of tests performed on the existing data acquisition configuration.